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INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(51) International Patent Classification 3 : F23C 3/00, F23G 7/06

A1

(11) International Publication Number: WO 85/ 01567

(43) International Publication Date: 11 April 1985 (11.04.85)

(21) International Application Number: PCT/SE84/00325

(22) International Filing Date: 1 October 1984 (01.10.84)

(31) Priority Application Number: 8305351-2

(32) Priority Date: 30 September 1983 (30.09.83)

(33) Priority Country: SE

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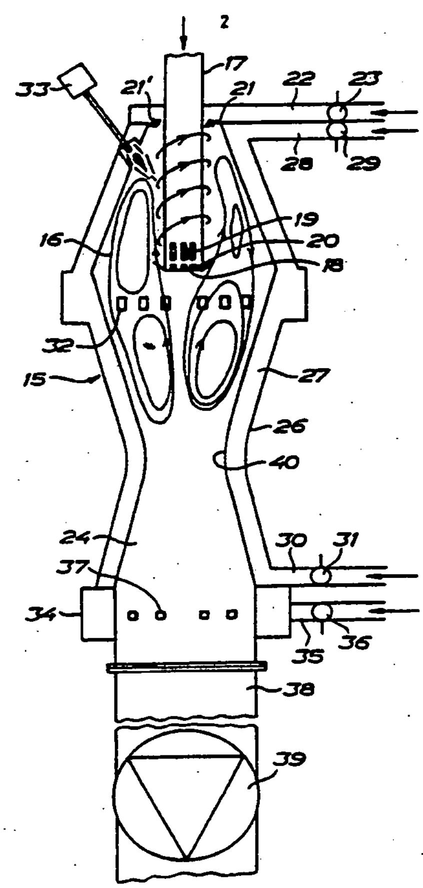
(81) Designated States: AT (European patent), AU, BE (European patent), BR, CH (European patent), DE (European patent), DK, FI, FR (European patent), GB (European patent), JP, LU (European patent), NL (European patent), NO, SE (European patent), US.

Published
With international search report.
In English translation (filed in Swedish).

(54) Title: BURNER

(57) Abstract

Burner for burning a fluid. The burner comprises a combustion chamber (16) between an inlet (21) for primary air and an outlet (40) for flue gas, and a conduit (17) opening into the combustion chamber, for the supply of the fluid. This conduit is extended into the combustion chamber to open in the region of a wider central portion of the combustion chamber tapering conically towards the two ends thereof.



BURNER

The present invention relates to a burner for the combustion of a fluid, comprising a combustion chamber between an inlet for primary air and an outlet for flue gas, and a conduit opening into the combustion chamber, for the supply of said fluid.

The invention has been proposed particularly for burning contaminated gas or gas the combustion of which involves other difficulties when conventional methods are applied as far as combustion and environment considerations are concerned. In this connection particularly the application on electrode furnaces for the production of aluminium by melting electrolysis of a solution of inter alia aluminia and cryolite may be mentioned, but the invention can be applied also to process gas e.g. from arch furnaces (electrode melting furnaces).

Generally, the invention can be applied to low grade and high grade gas, of any type, such as natural gas, and moreover not only to clean gas or gas with solid particulate contaminations but also to suspensions of solid particles in gas, e.g. coal powder suspensions in air. Other fluids to which the invention can be applied, are oil and e.g. coal powder suspensions in water.

In electrolysis furnaces for the production of aluminium, the so-called Söderberg-electrode may be provided. This electrode comprises a thin casing of metal sheet, forming a shaft, to which briquettes are supplied consisting of coal powder with tar as a binder. When the electrode is being used, the briquettes are baked or sintered at the lower end of the electrode. Thus, the electrode is produced directly in the furnace. As the electrode material is consumed, the casing is

lengthened by adding further sections, and briquettes are supplied to the shaft formed by the casing. Thus, it is not necessary to replace at intervals such an electrode by a new electrode. On the contrary, the electrode can operate continuously, because it will be renewed all the time concurrently with the burning-off at the lower end of the electrode when the electrode furnace is in operation. In this respect the electrode of the Söderberg-type is preferred before the electrode of the pre-baked type which necessitates discontinuous operation due to exchange of electrodes when an electrode has been consumed and has to be replaced by a new electrode. However, a drawback of the Söderberg-electrode is that when the briquettes are baked or sintered during the use of the electrode, flue gas is generated containing in addition to carbon monoxide and carbon dioxide also unburnt coal, tar and hydrocarbon products (bensapyren and others) to a considerably greater extent than in case of the electrode of the pre-baked type which is baked and sintered and thus "burnt-off" before it is installed into the electrode furnace. The flue gas escaping from an electrode furnace operating with electrodes of the pre-baked type as a consequence thereof is cleaner and easier to handle and causes less environmental problems than the flue gas from an electrode furnace operating with electrodes of the Söderberg-type.

In addition to the substances mentioned above, the flue gas from electrode furnaces which are used for melting electrolysis of a solution of alumina and cryolite in the production of aluminium, contains also alumina and fluor, said latter substance being present not only in gas phase but also in solid phase as fluor compounds (salts and fluorides). The solid components in the flue gas are separated in filters either

electro-filters or hose filters, not only for environmental reasons in order that cleaner flue gas shall be discharged into the surroundings, but above all in order to recover alumina and fluor compounds. However, tar which is present in the flue gas, causes problems in the filtering operation due to the fact that the filter, if it is a hose filter, is blocked by the tar and that the tar, if the filter is an electro-filter, forms a coating on the electrodes. Moreover, the tar causes trouble by adhering to the surfaces in the conduits through which the flue gas is evacuated, and also on the surfaces in heat exchangers, if any, for recovering heat energy from the flue gas. Therefore, attempts have been made to eliminate the tar (and also other combustible components of the flue gas) by having an oil flame at some location in the conduit for the flue gas, but it has been found that this method is inefficient; sufficient tar is present in the flue gas to cause problems with blocking and coating.

A high tar content of the flue gas necessitates cooling of the flue gas to a temperature which is sufficiently low so as to avoid the risk of ignition of the tar and other combustible constituents of the flue gas in filtering and other late treatment of the flue gas, and also to avoid the risk of ignition of the tar adhering to the surfaces in conduits and other apparatus. This means that the possibilities of recovering heat from the flue gas are limited to a great extent.

The purpose of the invention is to provide a burner of the type referred to above, which particularly facilitates a more effective cleaning of the flue gas from an electrode furnace with an anode of the Söderberg-type such that the final product of the flue gas after filtering is a completely clean burnt-out gas

which may escape to the surroundings without a risk for environmental damage being involved. By the invention it shall also be possible to control in a more favourable way the temperature of the flue gas such that a desired energy level of the flue gas can be selected e.g. for adaptation to heat exchangers for heat recovery or to other apparatus. Generally, it is aimed at by the invention to satisfy rigorous environmental demands as well as economical demands in the combustion of an arbitrary fluid.

For the purpose mentioned above the burner of the invention has obtained the characteristics appearing from claim 1, and in order to explain closer the invention embodiments thereof will be described in more detail below, reference being made to the accompanying drawings in which

FIG. 1 is a diagrammatic view of two electrode furnaces with an anode of the Söderberg-type and connected to a burner of the invention,

FIG. 2 is a diagrammatic vertical sectional view of one embodiment of the burner, and

FIG. 3 is a diagrammatic vertical sectional view of another embodiment of the burner.

In FIG. 1, to which reference is made, two electrode furnaces are shown each comprising a furnace chamber 10 the bottom of which is constructed as a cathode 11 while an anode 12 extends downwards from above into the furnace chamber. It is assumed that the anode is of the Söderberg-type and thus is constructed in the manner explained in more detail above. The furnace chamber 10 is provided with a hood or covering 13 for collecting the flue gas developed in the furnace chamber when the electrode furnace is in operation. If it is assumed that the electrode furnace is used for melting electrolysis of a solution of inter alia alumina

and cryolite, said flue gas will contain carbon monoxide, carbon dioxide, unburnt coal, tar, hydrocarbon products, alumina, fluor, and fluor compounds as mentioned above. A conduit 14 is extended from the hood or covering 13 for evacuating the flue gas from the furnace, and the conduit from each electrode furnace is connected to a burner 15 which is common to both furnaces, for afterburning the flue gas. Additional furnaces can be connected to a common burner.

The burner 15 is of an embodiment which is more clearly shown in FIG. 2 and comprises a combustion chamber 16 formed as two truncated cones the large ends of which are facing each other such that the combustion chamber has a wider central portion and tapers from this portion towards the upper and lower end, respectively. The conduits 14 are connected to a supply conduit 17 for the flue gas, which extends coaxially into the combustion chamber, which is symmetric around the longitudinal axis thereof, through the upper end of the chamber and terminates in the region of the wider central portion of the combustion chamber where the supply conduit is terminated by an end wall 18. Annularly arranged outlet apertures 19 formed as slots or gills, which are elongated in the axial direction of the supply conduit, are spaced a short distance above the end wall 18 while annularly arranged outlet apertures 20 are located below the openings 19 adjacent the end wall 18. A conduit 22 with a valve 23 is connected to an annular opening 21 between the supply conduit 17 and the wall of the combustion chamber at the upper end thereof where a turbulator 21' may be provided, for the supply of primary air to the combustion chamber via the turbulator. The lower end of the combustion chamber connects to a diffusor 24 which changes into an outlet socket 25, and the combustion

chamber 16 as well as the diffusor 24 is surrounded by an outer housing 26 which defines together with the wall of the combustion chamber an annular air passage 27 for the supply of secondary air which is admitted to the air passage 27 at the top through a conduit 28 with a valve 29 and at the bottom through a conduit 30 with a valve 31. Inlets 32 for secondary air are arranged in the wall of the combustion chamber in the wider central region thereof slightly below the closed lower end of the supply conduit 17.

An ignitor 33 is provided in the combustion chamber 16 and is located in the upper region of the combustion chamber adjacent the annular opening 21, and this ignitor can be of the type burning oil or gas or of the electric type. In the present case it is shown as an ignition burner the flame of which is directed downwards in an inclined direction into the combustion chamber 16.

Also the outlet socket 25 is surrounded by an outer housing 34 which is connected to a conduit 35 with a valve 36, for the supply of cooling air for which an outlet 37 is provided in the outlet socket 25 so that the air is supplied to the combustion chamber as tertiary air. A conduit 38 is connected to the outlet socket for carrying away the flue gas discharged from the burner 15, and a suction fan 39 can be connected into said conduit as shown herein.

When the burner 15 is in operation, the ignitor 33 is continuously energized, if this is necessary considering the gas quality, and the flue gas developed in the electrode furnaces is sucked by the fan 39 from the furnaces through the reactor then to be carried along through the conduit 38 to a filter, heat exchanger, or other apparatus before the flue gas is allowed to escape to the surroundings. Primary air, secondary air, and tertiary air is supplied to the

burner from a fan at a suitable pressure and at a suitable flow rate, which are controlled by means of the valves 23, 29, 31, and 36.

The flue gas is ejected radially from the supply conduit 17 through the slot apertures 19 to arrive at the combustion chamber, but part of the gas also is ejected through the apertures 20 and this gas carries along heavier solid particles entrained into the flue gas. The end wall 18 is formed at the periphery thereof as an annular deflector to direct the gas flow and solid particles entrained therein from the apertures 20 at a small angle upwards towards the upper end of the combustion chamber, but the gas may also be ejected from the supply conduit radially or this conduit may be open at the end thereof, the opening facing the opening 21 axially.

The primary air arrives at the combustion chamber 16 through the opening 21 via the turbulator 21' and thus a turbulent motion is imparted to the air in the combustion chamber. In the combustion chamber, the air meets the secondary air supplied through the apertures 32 and the flue gas supplied through the apertures 19 and 20. By the arrangement described there is obtained an intense turbulence of the air and the flue gas in the combustion chamber 16 the flue gas whirling upwards around the supply conduit 17 and then meets the primary air also rotating around the supply conduit 17. In cooperation with the secondary air supplied, whirls are formed in the combustion chamber in the manner indicated in FIG. 2. Combustible components of the flue gas such as tar, carbon monoxide and hydrocarbons, are ignited by the ignitor 33 and are burnt intensely in the combustion chamber by the thorough mixing of flue gas and air and the internal flue gas feedback taking place in the combustion chamber due to the form thereof. When the

flue gas (fuel) supplied through the conduit 17 flows upwards along the outside surface of the conduit, said gas will be thermally decomposed (cracking) before the combustion proper begins at the upper portion of the combustion chamber adjacent the opening 21. Then, the conduit 17 will be cooled by the thermal decomposition requiring energy. Moreover, there is obtained some pre-heating of the flue gas (fuel) supplied through the conduit 17. When other gas than such gas as is obtained from the production of aluminium, e.g. high grade or low grade fuel gas, which normally burns with a slightly luminous or non-luminous flame, there is obtained by the existing thermal decomposition a yellow luminous flame which radiates heat to the wall of the combustion chamber. As a consequence thereof a unitary and relatively low temperature is obtained in the combustion chamber. The radiated heat may amount to 40-50 % of the total heat emission which otherwise is effected by convection in the combustion chamber. If the conduit 17 is made adjustable, a satisfactory control can be obtained for optimizing the combustion conditions.

Since the supply of air to the combustion chamber is divided into two or preferably three zones, viz. primary air through the opening 21, secondary air through the apertures 32, and tertiary air through the apertures 37, there is obtained a unitary temperature distribution in the combustion chamber. As a consequence thereof a low content of PAH (polyaromatic hydrocarbon compounds) and NO_x will be obtained as well as carefully controlled combustion conditions and safe final combustion, i.e. a low content of unburnt components such as CO and C_nH_m, particularly for low grade fuel gas such as the flue gas from the production of aluminium. The duration of stay of the fuel in the combustion chamber will be relatively long, which also

promotes low contents of unburnt components.

The flue gas substantially burnt-out passes through the narrower opening 40 formed by the combustion chamber at the lower end thereof, into the diffusor 24. Since the flue gas must pass through the constriction, a load-dependent positive pressure can be maintained in the combustion chamber, which means that the flame length will be limited and that more constant temperature conditions will be maintained in the flame during the combustion. Under these conditions it is achieved that the combustion chamber 15 can be made more "compact" or limited. The pressure loss in the constriction will be regained in the diffusor 24 where final combustion of the flue gas takes place. In the socket 25, tertiary air (cooling air) is supplied through the apertures 37 in order to impart to the flue gas the temperature which is most suitable considering the following arrangements, i.e. the temperature of the flue gas is controlled to a value which it should have during the following filtering, heat exchange, etc. Thus, there is the possibility of choosing the exergy level of the flue gas discharged from the reactor, which is considered most suitable in view of the circumstances.

Probably, the gas flow to the burner in the specific application considered herein is not constant but will vary. Such variation can arise e.g. in the manufacture of aluminium, due to the fact that the crust covering the charge in the furnace, is broken from time to time for charging the furnace or for tapping molten aluminium from the furnace by a siphon. In the burner of the invention, compensation is made for such variations by the ignitor 33 being operated continuously for igniting the flue gas if it cannot be self-ignited due to an existing reduction of the supply of flue gas, and by the combustion zone in the combustion chamber 16

being of great length due to the existing turbulence and being followed by final combustion in the diffusor 24. Equalization of variations in the supply of the flue gas can also be obtained by connecting several furnaces to a common reactor.

By the specific design of the supply conduit 17 at the opening end thereof there is obtained a self-cleaning, because major solid particles are given no chance of collecting in the supply conduit but are blown-out through the apertures 20. However, it may be necessary to design the inlet conduit 17 in another way if fluids of other kinds are to be burnt. Moreover, there is obtained cooling of the wall of the combustion chamber by the secondary air being supplied in the passage 27 defined by means of the housing 26, such that the temperature of the wall of the combustion chamber can be kept at an acceptable value, the secondary air at the same time being pre-heated before it is supplied to the combustion chamber. The diffusor 24 prevents pressure drops and adhesion of solid particles in the outlet from the combustion chamber.

The embodiment of FIG. 3 principally is constructed in the same way as the embodiment of FIG. 2, but there are some constructive differences between the two embodiments. In the first place, the combustion chamber is not provided with a cooling passage (cooling housing) and in the second place the secondary air is supplied in a somewhat different way. Thus, there is provided at the end of the combustion chamber where the opening 21 with the turbulator 21' for the primary air is arranged, an internal cone 41 which defines together with the wall of the combustion chamber a gap 42. While the conduit 22 opens through the aperture 21 into the cone 41, the conduit 28 opens into the gap 42. Also the ignition burner 33 opens into the cone 41. The ignition of the

flue gas (fuel) supplied thus is effected inside the cone 41, while primary air is being supplied. Then, the combustion continues below the cone, while secondary air is being supplied. The operation otherwise is the same as in the embodiment of FIG. 1, and also in this case the flue gas supplied, which flows into the combustion chamber 16 through the apertures 20, is forced to flow towards the opening 21 along the outside surface of the supply conduit 17 under the influence of the end wall 18 arranged as a deflector, and the counter-pressure produced at the constriction 40.

When it is said herein that the supply conduit 17 opens into the region of a wider central portion of the combustion chamber 16, it is intended that this region may comprise not only a central cylindrical portion, if any, as in the embodiment of FIG. 3, but also parts of the conical end portions joining a cylindrical portion or joining each other, to one third of the height thereof.

The invention provides a burner which requires restricted service and maintenance and which easily can be adapted to different fluid fuels. The burner is a low emission and low temperature burner which is particularly well suited for the application described with reference to FIG. 1 as well as combustion of conventional gaseous or fluid fuels, no admixture of air to the fuel being necessary at the fuel supply as is otherwise often required.

CLAIMS

1. Burner for burning a fluid, comprising a combustion chamber (16) between an inlet (21) for primary air and an outlet (40) for flue gas, and a conduit (17) for the supply of the fluid, opening into the combustion chamber, characterized in that the conduit (17) for the supply of the fluid is extended into the combustion chamber (16) to open in the region of a wider central portion of the combustion chamber tapering conically towards the two ends thereof.

2. Burner as claimed in claim 1, characterized in that the combustion chamber (16) at said other end (40) thereof is connected to an outlet (25) by a diffusor (24).

3. Burner as claimed in claim 1 or 2, characterized in that inlets (32) for secondary air are arranged in the wall of said wider portion.

4. Burner as claimed in claim 3, characterized in that the outlet apertures of the inlet conduit (17) open into the combustion chamber (16) upstream of the inlets (32) for the secondary air.

5. Burner as claimed in claim 3 or 4, characterized in that the combustion chamber (16) and the diffusor (24), if any, are surrounded by a housing (26) for the supply of secondary air to the inlets (32) for secondary air.

6. Burner as claimed in claim 1 or 2, characterized in that the inlet (21) for primary air is arranged in an internal cone (41) located inside the combustion chamber (16), said cone defining together with the wall of the combustion chamber a passage (42) for the supply of secondary air.

7. Burner as claimed in any of claims 1 to 6, c h a r a c t e r i z e d in that the inlet conduit (17) is closed at the end thereof inside the combustion chamber (16) and is arranged with circumferential outlet apertures (19, 20).

8. Burner as claimed in any of claims 1 to 7, c h a r a c t e r i z e d in that the inlet for primary air is arranged annularly around the inlet conduit (17) and is provided with a turbulator (21) to provide rotation of the primary air around the inlet conduit (17) in the combustion chamber (16).

9. Burner as claimed in any of claims 1 to 8, c h a r a c t e r i z e d in that an ignitor (33) is located adjacent the inlet (21) for the primary air.

10. Burner as claimed in any of claims 1 to 8, c h a r a c t e r i z e d in that the outlet is arranged as an outlet socket (25) having inlets (37) for tertiary air in the wall thereof.

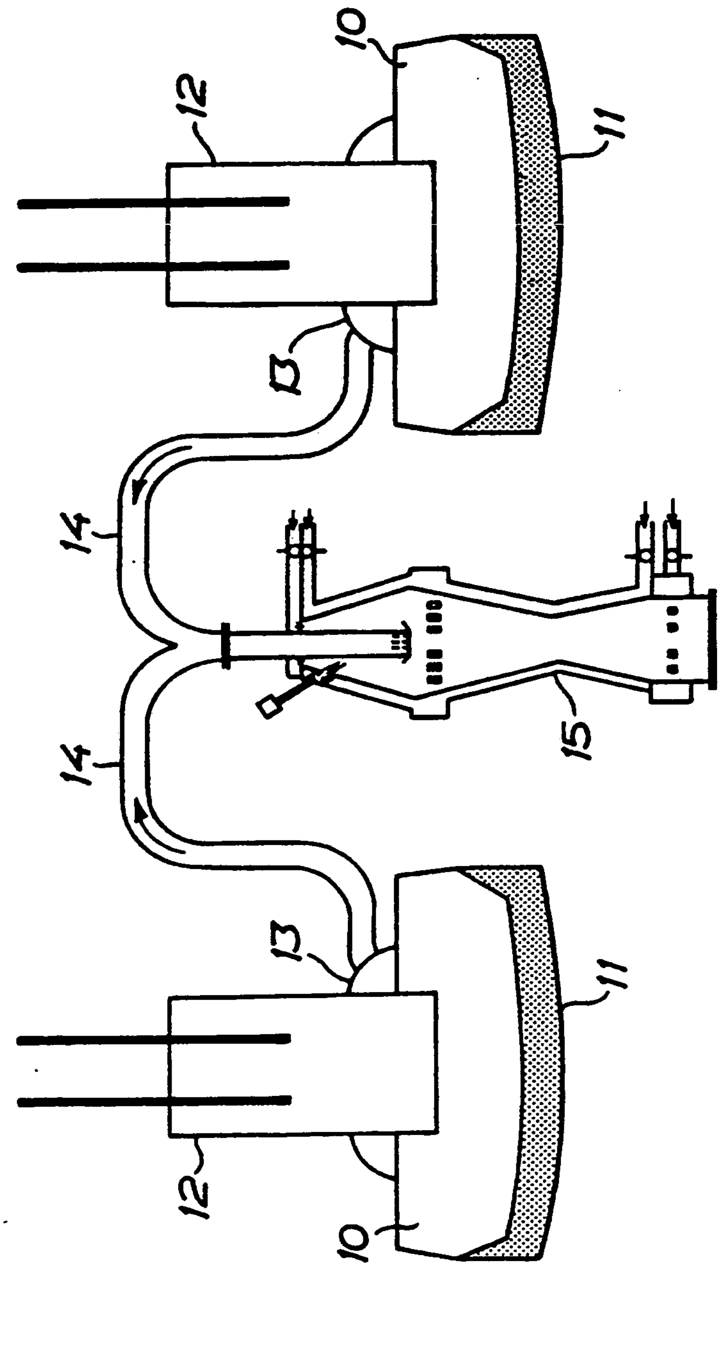


FIG. 1

SUBSTITUTE SHEET

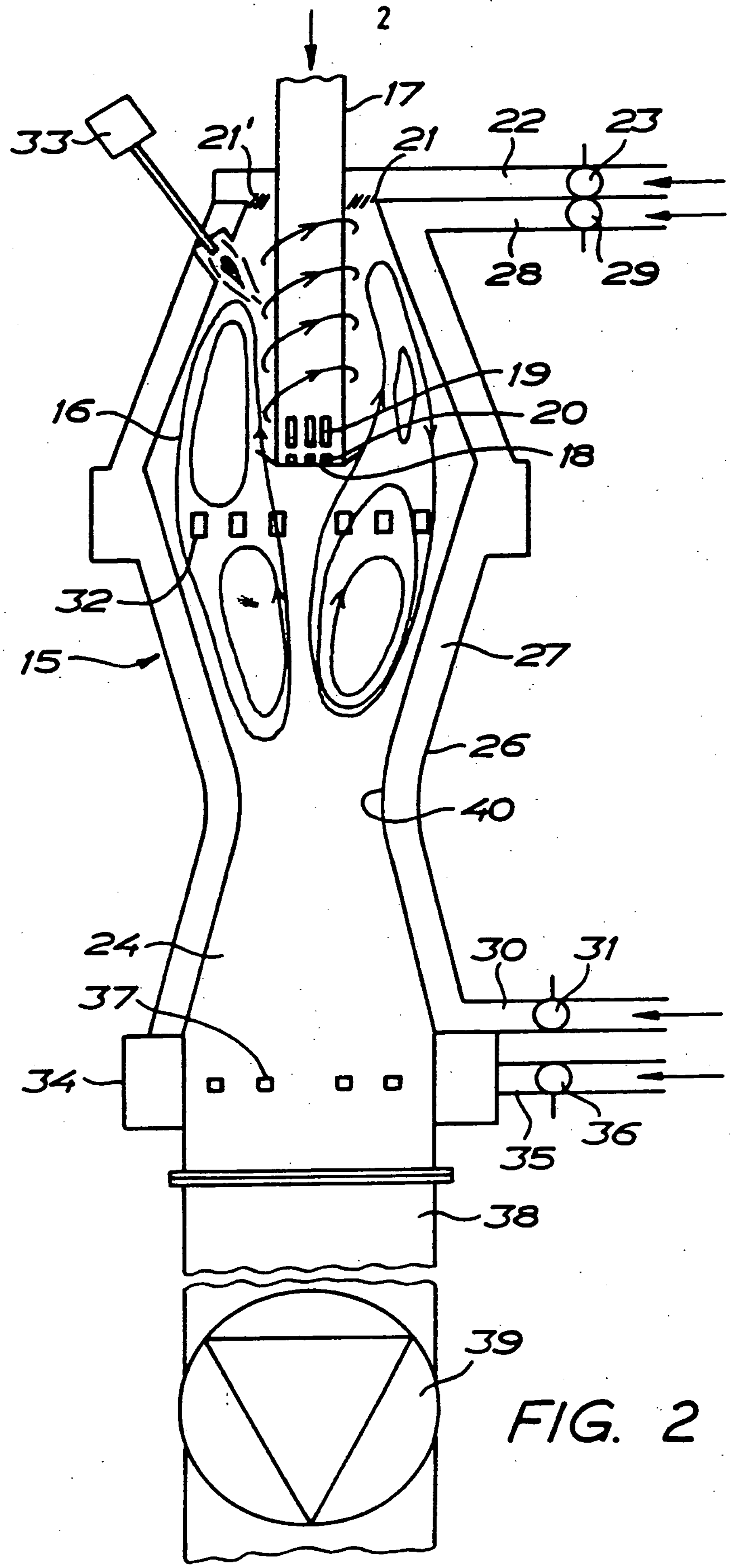

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FIG. 2

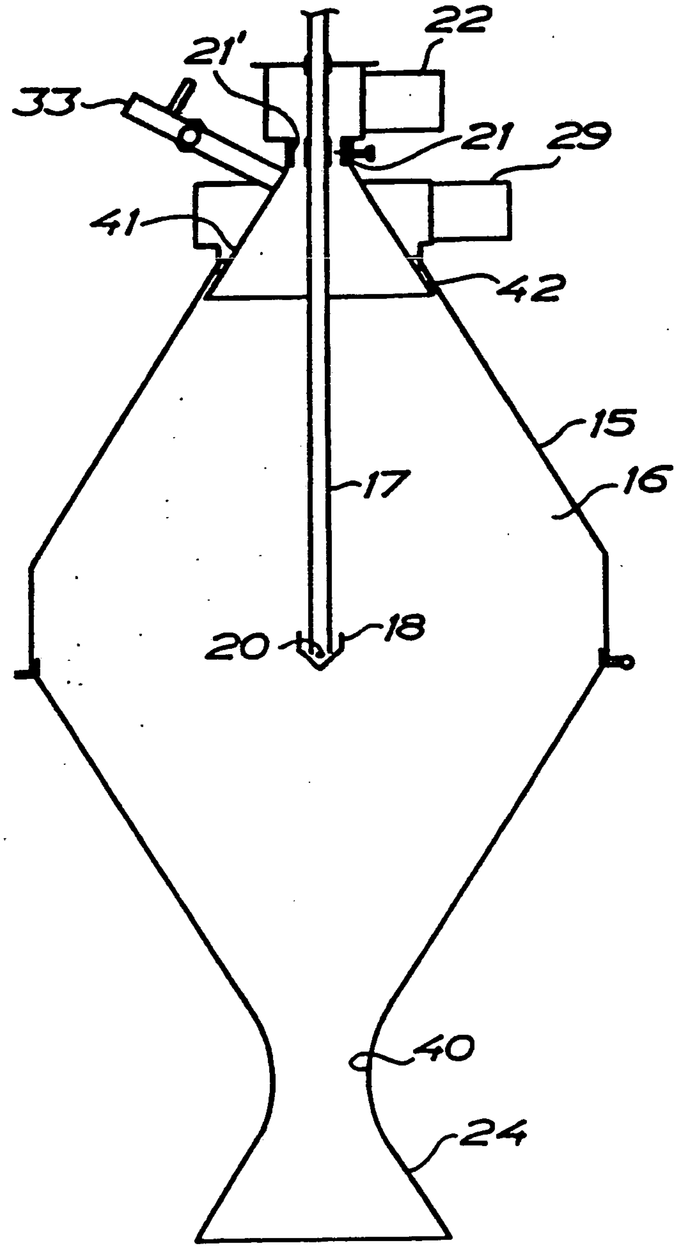

FIG. 3

INTERNATIONAL SEARCH REPORT

International Application No PCT/SE84/00325

I. CLASSIFICATION OF SUBJECT MATTER (if several classification symbols apply, indicate all) [3]

According to International Patent Classification (IPC) or to both National Classification and IPC 3

F 23 C 3/00, F 23 G 7/06

II. FIELDS SEARCHED

Minimum Documentation Searched [4]

Classification System	Classification Symbols
IPC 3	F 23 C 3/00, 5/00, 5/18; F 23 D 15/00, 02, 04; F 23 G 7/00, 06 .../...
National Cl	24c:1, 10

Documentation Searched other than Minimum Documentation to the Extent that such Documents are Included in the Fields Searched [5]

SE, NO, DK, FI classes as above

III. DOCUMENTS CONSIDERED TO BE RELEVANT [14]

Category *	Citation of Document, [16] with indication, where appropriate, of the relevant passages [17]	Relevant to Claim No. [18]
Y	Derwent's abstract No. 83-704244/27, SU 953 372	1, 8
Y	DE, B, 1 062 873 (AKTIENGESELLSCHAFT BROWN, BOVERI & CIE) 6 August 1959	1, 3, 5, 7-9
A	SE, B, 410 802 (ENERGIAGAZDALKODASI INTEZET) 5 November 1979, See Fig. 2	1-5
A	DE, B, 2 700 786 (HERMANN RAPPOLD & CO GMBH) 26 July 1979, See fig. 1-2	1-3, 5, 10
A	NO, B, 138 046 (NILS ÖSTBO AB) 6 March 1978	6
A	EP, A, 0 053 911 (JOHN ZINK COMPANY) 16 June 1982	7

* Special categories of cited documents: [15]
"A" document defining the general state of the art which is not considered to be of particular relevance
"E" earlier document but published on or after the international filing date
"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)
"O" document referring to an oral disclosure, use, exhibition or other means
"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step
"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.
"&" document member of the same patent family

IV. CERTIFICATION

Date of the Actual Completion of the International Search [2]	Date of Mailing of this International Search Report [2]
1984-11-19	1984 -11- 23
International Searching Authority [1]	**Signature of Authorized Officer [20]**
Swedish Patent Office	Å. Vängborg Å. Vängborg

L.E.

International Application No. PCT/SE84/00325

FURTHER INFORMATION CONTINUED FROM THE SECOND SHEET

II Fields Searched (cont).

US Cl 431:5, 159, 165, 177

V. ☐ OBSERVATIONS WHERE CERTAIN CLAIMS WERE FOUND UNSEARCHABLE [10]

This international search report has not been established in respect of certain claims under Article 17(2) (a) for the following reasons:

1. ☐ Claim numbers ...., because they relate to subject matter [12] not required to be searched by this Authority, namely:

2. ☐ Claim numbers ...., because they relate to parts of the international application that do not comply with the prescribed requirements to such an extent that no meaningful international search can be carried out [13], specifically:

VI. ☐ OBSERVATIONS WHERE UNITY OF INVENTION IS LACKING [11]

This International Searching Authority found multiple inventions in this international application as follows:

1. ☐ As all required additional search fees were timely paid by the applicant, this international search report covers all searchable claims of the international application.
2. ☐ As only some of the required additional search fees were timely paid by the applicant, this international search report covers only those claims of the international application for which fees were paid, specifically claims:
3. ☐ No required additional search fees were timely paid by the applicant. Consequently, this international search report is restricted to the invention first mentioned in the claims; it is covered by claim numbers:
4. ☐ As all searchable claims could be searched without effort justifying an additional fee, the International Searching Authority did not invite payment of any additional fee.

Remark on Protest

☐ The additional search fees were accompanied by applicant's protest.

☐ No protest accompanied the payment of additional search fees.